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**United States Patent** [19][11] **Patent Number:** **5,206,506****Kirchner**[45] **Date of Patent:** **Apr. 27, 1993****[54] ION PROCESSING: CONTROL AND ANALYSIS****[76] Inventor:** **Nicholas J. Kirchner**, 250 Del Medio Ave., No. 201, Mountain View, Calif. 94040**[21] Appl. No.:** **654,374****[22] Filed:** **Feb. 12, 1991****[51] Int. Cl.<sup>5</sup> .....** **B01D 59/44; H01J 49/40****[52] U.S. Cl. ....** **250/281; 250/283****[58] Field of Search ....** **250/283, 287, 290, 291, 250/292****[56] References Cited****U.S. PATENT DOCUMENTS**

2,606,291	8/1952	Wilson .....	250/292
2,768,304	10/1956	Wells et al. ....	250/287
2,939,952	6/1960	Paul et al. .	
3,258,591	6/1966	Blauth et al. ....	250/290
3,501,631	3/1970	Arnold .	
3,621,242	11/1971	Ferguson et al. ....	250/287
3,715,590	2/1973	Auer .....	250/389
3,819,941	6/1974	Carrico .	
4,059,761	11/1977	Dawson .....	250/287
4,066,893	1/1978	Dawson .	
4,105,917	8/1978	McIver et al. .	
4,117,321	9/1978	Meyer .	
4,380,046	4/1983	Fung .	
4,704,532	11/1987	Hua .	
4,727,474	2/1988	Batcher .	
4,755,670	7/1988	Syka et al. .	
4,755,671	7/1988	Friedland et al. .	
4,805,091	2/1989	Thiel et al. .	
4,878,735	11/1989	Vilums .	
4,882,484	11/1989	Franzen et al. .	
4,900,414	2/1990	Sibadis .....	204/180.1
4,914,612	4/1990	Beece et al. .	
5,089,702	2/1992	Allemann et al. ....	250/291

**FOREIGN PATENT DOCUMENTS**

03218119 6/1989 European Pat. Off. .

**OTHER PUBLICATIONS**

Leclerc, G. Sanche, L., "Spreadsheets for Computing Charged-Particle Trajectories in 3-d Electrostatic

Fields", Computers in Physics, Nov./Dec., pp. 617-626, 1990.

Schwarzschild, B., "Antiprotons Cooled to 4K and Weighed in a Penning Trap", Physics Today, pp. 17-20, Jul. 1990.

Dehmelt, H., "Radiofrequency Spectroscopy of Stored Ions: Storage", Advances in Atomic and Molecular Physics, vol. 3, ed. Bates, D. and Estermann, I., Academic Press, New York, 1967, pp. 53-72.

Todd, J., "Ion Trap Mass Spectrometer—Past, Present and Future(?)" Mass Spectrometry Reviews, vol. 10, John Wiley &amp; Sons, Inc., 1991, pp. 3-52.

Cornell, E., et al., "Single-Ion Cyclotron Resonance Measurement of M(CO+)/M(N2+)", Physical Review Letters, vol. 63, No. 16, Oct. 16, 1989, pp. 1674-1677.

(List continued on next page.)

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An ion processing unit (10) comprising a series of M perforated electrode sheets (12), driving electronics (14,16) and a central processing unit (18), allow formation, shaping and translation of multiple effective potential wells (42). Ions, trapped within a given effective potential well (42), can be isolated, transferred, cooled or heated, separated, and combined. Measurement of induced image currents allows measurement and typing of ion species by their respective mass-to-charge ratios. The combination of many electrode sheets (12), each having N multiple perforations (22), creates any number of parallel ion processing channels (26). The ion processing unit (10) provides an N by M massively parallel ion processing system, furnishing means for processing large numbers of ions in parallel in the same manner, but with different ion processes deployed at different sections of each ion processing channel (26). In addition, the space-filling parallel structure of the present invention provides an efficient means for storage of large numbers of ions, including charged antimatter.

**36 Claims, 32 Drawing Sheets**